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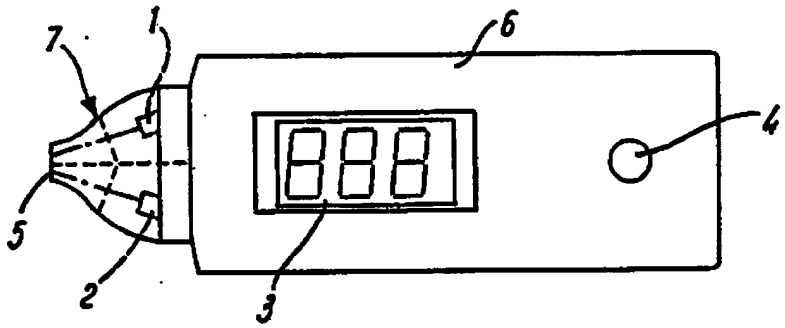

(57) Abstract

A shade distinguishing device comprising a casing (6) having a light source (1) and detector (2). The light source and detector being relatively positioned so that a proportion of the light emitted by the detecteur, and falling incident on an object, is reflected onto the detector. The proportion of the light detected being dependent on the colour and shade of the object. The signal from the detector being processed to produce an accurate signal representative of the shade and colour of the object, which is displayed on a liquid crystal display (3).

* See back of page

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"Shade Distinguishing Device"

This invention relates to a shade distinguishing device.

In addition to the primary task of caring for patients' teeth and gums dentists today also have to be aware of the cosmetic side of their work. Patients whether they require fillings, caps, veneers or dentures want them to blend and match their own teeth. The most important part of this matching process is colour or shade matching.

At present shade matching is achieved by a dentist who visually matches the shade of a patients' teeth with a 16 shade guide. This is both an extremely time consuming and an inadequate process. With only 16 shades to choose from many patients' teeth cannot be matched perfectly. This problem is compounded both by dentists not always having time for an accurate matching and by the shading on the charts fading with age. These problems added to the fact that many dentists and technicians do not have perfect colour vision results, in many cases in an extremely poor shade match and visually obvious dental work for the

patient.

The provision of a device which can provide an accurate measure of teeth shading is therefore extremely desirable.

According to the present invention there is provided a shade distinguishing device comprising a light source for projecting light towards an object, light detecting means for receiving light reflected from said object and which produces an output signal the magnitude of said signal being dependent on the intensity of light incident on the detecting means and means for producing an audio or visual display representative of the magnitude of said signal.

Preferably, the light source is a light emitting diode.

Most preferably, there is a plurality of light sources, each producing light at a different wavelength, particularly in the ranges including red, yellow, green and blue light.

Preferably, the detecting means is a diode which produces a voltage signal the magnitude of the signal being dependent on the intensity of the incident light.

Preferably, the detector is shielded in order to limit the detection of scattered or spurious light.

Preferably, signals produced by the detection of spurious light are deleted by the modulation of the light source at a known frequency and the use of phase sensitive detection of the reflected light, at the said frequency.

Most preferably phase sensitive detection is provided by the inclusion of a lock-in amplifier system.

Preferably, the light source and detector are relatively positioned so that light emitted by the source will be detected by the detector only if the light is reflected from a surface at a set distance from the light source and detector.

Most preferably, the surface is a tooth and the intensity of light on the detector is dependent on the proportion of the light, incident on the tooth, which is reflected by the tooth enamel.

Preferably, the signal is processed by an analogue to digital converter to drive a digital display.

Most preferably, the analogue to digital converter is in the form of a pre-programmed micro-chip.

Preferably, the digital display is a seven segment liquid crystal display.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 is a side elevation of a shade distinguishing device in accordance with the present invention;
Fig. 2 is a plan view of the shade distinguishing device if Fig. 1; and
Fig. 3 is a block diagram of the shade distinguishing device of Fig. 1.

Referring to the drawings, Figs. 1 and 2 show a shade distinguishing device including a plastics housing 6 one end of which is attached to an operating head 7 containing a light source in the form of a light emitting diode 1 and a light detector 2 in the form of a diode which produces a voltage signal the magnitude of the signal being dependent on the intensity of the light incident on the detector 2. The main body of the housing 6 contains a means of processing the signal, in the form of a pre-programmed micro-chip which converts the analogue signal produced by the detector 2 to a digital signal which is displayed on an array of three liquid crystal diodes 3.

Fig. 3 is a block diagram showing how the shade distinguishing device will show a unique number on the display corresponding to the colour and shade of the object under test.

The sample is illuminated sequentially by various colour light emitting diodes and the light reflected back from the sample is measured using a photodiode.

In any practical measurement the signals will be accompanied by unwanted noise energy that limits the sensitivity that can be obtained. An a.c. phase sensitive measurement system is used in order to improve the signal to noise ratio and provide some immunity to strong light entering the detector. The phase sensitive detector has the ability to resolve a signal from broadband noise many times the amplitude of the signal to be measured. A lock-in amplifier measurement system is used which incorporates a modulation circuit, selective amplification, synchronous demodulation and low pass filtering.

The light emitting diodes are modulated at a discreet frequency in a region of minimal noise well removed from low frequency flicker noise and interference such as mains pick-up. Logic circuitry sequentially turns on each light emitting diode for a short period in turn. A driver circuit is used to provide sufficient current drive to the light emitting diodes.

The signal from the detector first undergoes wideband filtering and amplification. A band pass filter is used to remove any large interference signals which could saturate the output of the phase detector.

The modulated signal is synchronously detected using the reference signal to form the product in a multiplier circuit. This enables the system to discriminate against random noise components. The reference signal is derived from the same source as the signal and must be phase coherent. The output from the synchronous detector is then converted to a d.c. signal by an integrator and low pass filter. This provides a narrow bandwidth and removes any higher order a.c. components in the signal. The d.c. signal is then converted to a digital code using an analogue to digital convertor. At the end of conversion the output from the A/D convertor is latched into a shift register for storage.

A separate shift register is used for each light emitting diode. The outputs from the shift registers are connected to the address lines of then memory device and are used to select a unique address on the chip. The address selected will therefore depend on the level of the measurement signal. The memory device is pre-programmed with a unique number in each

location. The memory devices are configured as READ ONLY and therefore the date lines will correspond to the binary code of the location selected by the address lines. The data from the memory device is processed into a suitable form for the digital display which is updated at the end of each cycle of measurements.

The means of actuating the shade distinguishing device is in the form of an operating button 4.

In use a dentist or other user would place the open end 5 of the operating head 7 over a patients' tooth, thus positioning the light emitting diode 1 and light detector 2 at a set distance from the tooth. In this way the maximum amount of light emitted by the diode 1 and reflected off of the tooth falls incident on the detector 2.

The light incident on the tooth is either absorbed, transmitted or reflected. The proportion of the light reflected is dependent on the shade of the tooth; a black tooth reflecting no light and a pure white tooth reflecting all of the incident light. Therefore, the proportion of the light reflected is determined by the shade of the tooth and the voltage signal produced by the detector is determined by the intensity of this light incident on the detector.

Thus the voltage signal produced by the detector provides an accurate measure of the shade of a tooth. The voltage signal is converted from an analogue to a digital signal for ease of display, using a three digit liquid crystal diode display 3.

The voltage signal provided by the shade distinguishing

device can be compared to the signal obtained from each of the 16 shades available from a Vita (TM) shade guide. As the shades of porcelain produced by Vita (TM) and other manufacturers increase the electronic shade indicator will enable the exact matching of any tooth shade to that of a porcelain, which can be used to produce dentures or crowns or other dental requirements.

In this way the introduction of a shade distinguishing device in accordance with the present invention not only enables more accurate use of the presently available shades of porcelain but also facilitates the introduction and use of a much wider range of shades of porcelain.

Modifications and improvements may be incorporated without departing from the scope of the invention.

Claims

1. A shade distinguishing device comprising a light source for projecting light towards an object, light detecting means for receiving light reflected from said object and which produces a signal, the magnitude of said signal being dependent on the intensity of light incident on the detecting means and means for producing an audio or visual display representative of the magnitude of said signal.

2. A shade distinguishing device as claimed in Claim 1, wherein the light source is a light emitting diode.

3. A shade distinguishing device as claimed in Claim 2, wherein the device includes a plurality of light emitting diodes each providing light at a different wavelength, thus allowing the device to distinguish between colours.

4. A shade distinguishing device as claimed in Claim 3, wherein a logic circuit is provided to operate each light emitting diode in sequence.

5. A shade distinguishing device as claimed in any preceeding claim, wherein the detector is shielded in order to limit the detection of scattered or spurious light.

6. A shade distinguishing device as claimed in any preceeding claim, wherein the signals produced by scattered or spurious light are deleted by the modulation of the light source at a known frequency and the use of phase sensitive detection of the reflected light at the said frequency.

7. A shade distinguishing device as claimed in Claim 6, wherein a lock-in amplifier system is used.

8. A shade distinguishing device as claimed in any preceeding claim, wherein the light source and detector are relatively positioned so that light emitted by the light source will be detected by the detector only if the light is reflected from a surface at a set distance from the light source and detector.

9. A shade distinguishing device as claimed in Claim 8, wherein the surface is a tooth and the intensity of light incident on the detector is dependent on the proportion of the light, incident on the tooth, which is reflected by the tooth enamel.

10. A shade distinguishing device as claimed in any preceeding claim wherein the signal is processed by an analogue to digital convertor in the form of a pre-programmed micro-chip, to drive a digital display.

11. A shade distinguishing device as claimed in any preceeding claim, wherein the device is powered by a power cell such as a battery.

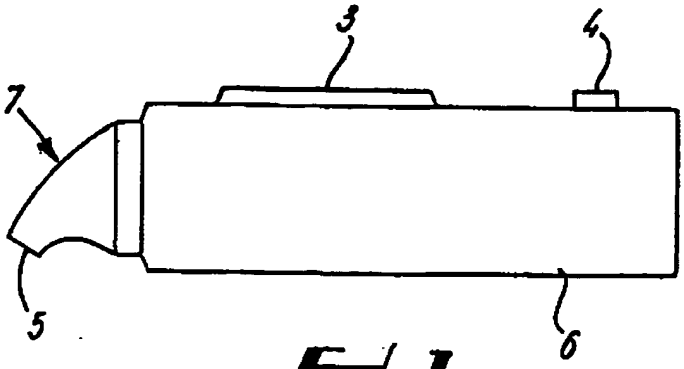

FIG. 1

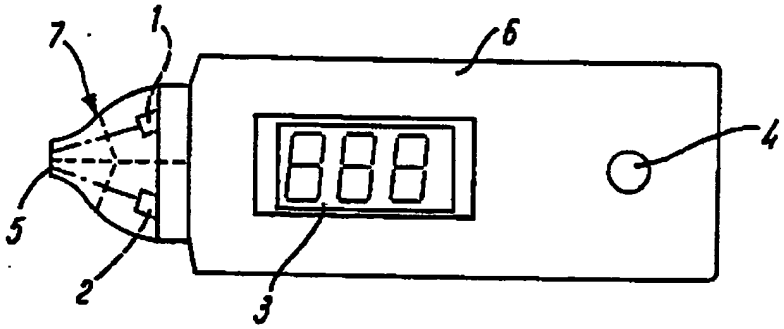

FIG. 2

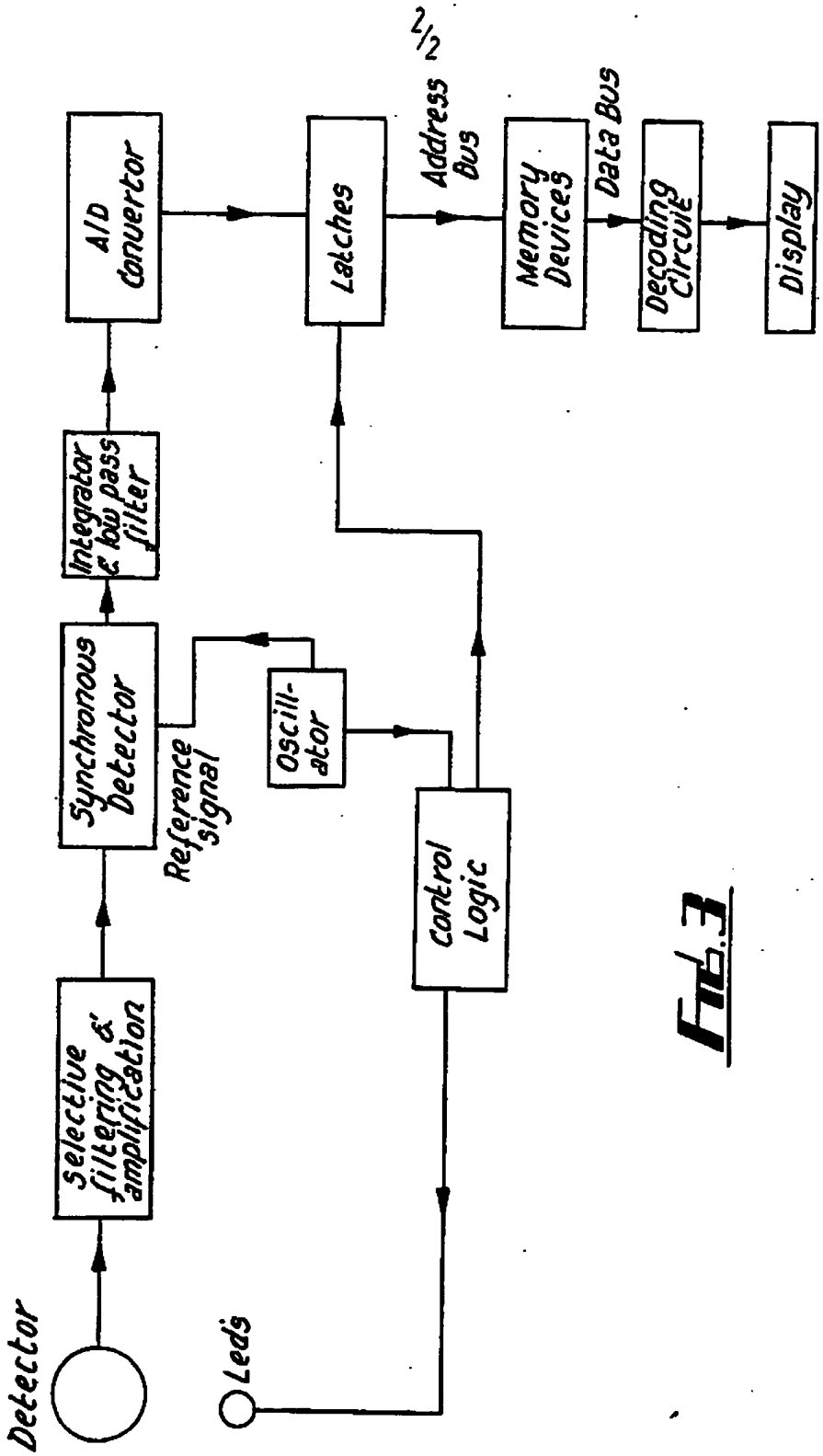
A/D convertor
Latches
Address Bus
Memory Devices
Data Bus
Decoding Circuit
Display
Integrator & low pass filter
Synchronous Detector
Reference signal
Oscill-ator
Control Logic
Selective filtering & amplification
Detector
Leds

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01288

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 01 J 3/50, A 61 C 19/10

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 01 J, A 61 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
P,X	EP, A, 0360657 (BERTIN & CO) 28 March 1990 see column 4, lines 2-51; figure 1 --	1,9,10
P,X	Patent Abstracts of Japan, volume 13, no. 427 (C-639), 22 September 1989, & JP, A, 01164361 (SHIGERU ONOZUKA) 28 June 1989 see abstract --	1
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12th November 1990	13. 12. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	F.W. HECK

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9001288

SA 39170

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 05/12/90
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